

**DRAFT**

**Department of Water Resources  
State Water Resources Control Board  
Department of Health Services**

**2002 RECYCLED WATER TASK FORCE**

**Science and Health/Indirect Potable Reuse Workgroup  
Draft White Paper**

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STATE OF CALIFORNIA  
2002 RECYCLED WATER TASK FORCE

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Draft White Paper**

Takashi Asano  
Professor Emeritus  
Department of Civil and Environmental Engineering  
University of California, Davis

**I. Wastewater reclamation, recycling and reuse**

Water reuse accomplishes two fundamental functions: (1) the treated effluent is used as a water resource for beneficial purposes, and (2) the effluent is kept out of streams, lakes, and beaches; thus, reducing pollution of surface water and groundwater.

The foundation of water reuse is built upon three principles: (1) providing reliable treatment of wastewater to meet strict water quality requirements for the intended reuse application, (2) protecting public health, and (3) gaining public acceptance. Whether water reuse is appropriate for a specific locale depends upon careful economic considerations, potential uses for the reclaimed water, and the relative stringency of waste discharge requirements. Public policies can be implemented that promote water conservation and reuse rather than the costly development of additional water resources with considerable environmental expenditures. Through integrated water resources planning, the use of reclaimed water may provide sufficient flexibility to allow a water agency to respond to short-term needs as well as increase the reliability of long-term water supplies.

In the planning and implementation of water reuse, the intended water reuse applications govern the degree of wastewater treatment required and the reliability of wastewater treatment processing and operation. In principle, wastewater or any marginal quality waters can be used for any purpose as long as adequate treatment is provided to meet the water quality requirements for the intended use. Various water reuse applications in California from reclaimed municipal wastewater are shown in Figure 1. The dominant applications for the use of reclaimed water include: agricultural irrigation, landscape irrigation, industrial recycling and reuse, and groundwater recharge. Among them, agricultural and landscape irrigation are widely practiced with well-established health protection guidelines and agronomic practices (Department of Health Services Wastewater Recycling Criteria, 2001). Agricultural and landscape irrigation constitutes approximately 70 percent of all categories of water reuse in California (cf., Figure 1).

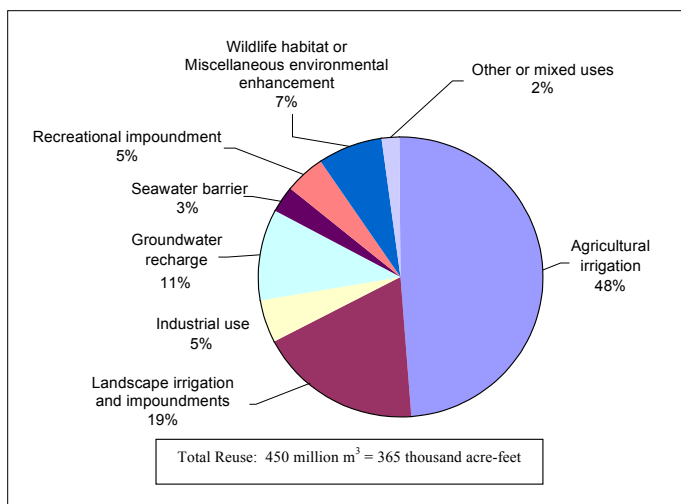


Figure 1 Wastewater reclamation and reuse in California (2001 SWRCB/OWR database)

## II. Spectrum of reclaimed water quality

As water is used for various domestic and industrial applications, the quality deteriorates due to introduction of various constituents and contaminants. A conceptual comparison of the extent to which water quality changes through municipal applications is shown in Figure 2. Today, technically proven water reclamation or water purification processes exist to provide water of almost any quality desired.

### Health risk assessment for water reuse

Despite a long history of water reuse in California, the question of *safety* of water reuse is still difficult to define and delineation of *acceptable* health risks has been hotly debated.

#### 1. Microbiological

Enteric viruses have received the most attention because of their low-dose infectivity, long-term survival in the environment, monitoring difficulties, and the limited extent of removal and inactivation that occurs in conventional wastewater treatment.

Health risks associated with exposure to enteric viruses in reclaimed water were analyzed using a quantitative microbial risk assessment approach in 1990s. Monitoring data from four wastewater treatment facilities in California on enteric virus concentrations in unchlorinated secondary effluents were used as baseline data for the risk analysis. To assess potential health risks associated with the use of reclaimed water in various reuse applications, four exposure scenarios were tested: (1) golf course irrigation, (2) food crop irrigation, (3) recreational impoundments, and (4) groundwater recharge.

Because enteric virus concentrations in unchlorinated secondary effluents were found to vary over a wide range, it was essential to characterize their variability. Two concepts related to the safety of water reuse were used: (1) the *reliability*, defined as the probability that the risk of infection does not exceed an acceptable risk, and (2) the *expectation*, defined by specifying an acceptable annual risk in which exposure to the enteric viruses may be estimated stochastically by numerical simulation such as Monte Carlo methods.

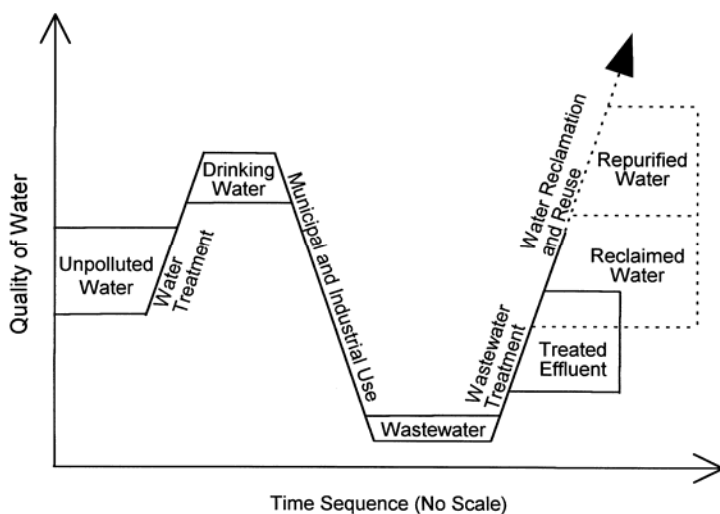


Figure 2. Water quality changes during municipal uses of water in a time sequence and the concept of wastewater reclamation, recycling and reuse (Asano, T., *Water Science & Technology*, Vol. 45, No. 8, p. 29, 2001.)

The U.S. EPA Surface Water Treatment Rule (SWTR) (U.S. EPA, 1989) defines an acceptable risk as less than or equal to one pathogen-derived infection per 10,000 population per year from use of a public water supply.

Therefore, if a  $10^{-4}$  annual risk of infection (less than or equal to one infection per 10,000 population per year) is set as an acceptable risk for water reuse, the reliability can be calculated as the percent of time that infection risk due to exposure to enteric viruses in reclaimed water is less than the acceptable risk. Reliability estimations for each exposure scenario are presented in Table 1.

From the results of the analysis presented in Table 1, the reliability or relative safety of water reuse can be assessed in comparison to domestic water supplies that meet the SWTR. When the disinfected, filtered secondary effluent (tertiary treatment) is chlorinated at about 10 mg/L, there is virtually no difference in the probability of enteric virus infection whether reclaimed water or domestic water is used for golf course irrigation, crop irrigation, and groundwater recharge. However, depending on the water quality of the secondary effluent, there is a considerable difference in health risks associated with exposure to recreational impoundments where body contact sports and swimming may take place. Similar observations can be made for the use of chlorinated secondary effluent and the reclaimed water from contact filtration with chlorine doses of below 5 mg/L.

Table 1. Reliability of various water reuse applications meeting the criterion of one enteric virus infection per 10,000 population per year

Treatment process	Secondary effluent from plant	Reliability, %			
		Golf course Irrigation	Crop irrigation	Recreational impoundment	Groundwater recharge
Full treatment or contact filtration with 10 mg/L chlorine dose achieving 5.2 log removals of viruses	A	100	100	77	100
	B	100	100	99	100
	C	100	100	98	100
	D	99	100	62	100
Chlorination of secondary effluent with 5 mg/L chlorine achieving 3.9 log removals of viruses	A	95	100	10	100
	B	100	100	81	100
	C	99	100	93	100
	D	84	100	11	100
Contact filtration with 5mg/L chlorine dose achieving 4.7 log removals of viruses	A	100	100	48	100
	B	100	100	96	100
	C	100	100	97	100
	D	97	100	39	100

Adapted from Tanaka, *et al.*, *Water Environmental Research*, Vol. 70, No. 1, 1998.

## 2. Chemical

Public concerns and perception on drinking water safety are the challenge for any water agency. Water reuse involving groundwater recharge will also be regarded as drinking water.

Four water quality factors are of particular concern: (1) microbiological quality, (2) total mineral content (e.g., total dissolved solids), (3) presence of toxicant of the heavy metal type, and (4) the concentration of stable organic substances. Particularly for the last two categories, recent studies in environmental toxicology and pharmacology have revealed potential long-term health risks associated with chemical compounds such as disinfection byproducts (DBPs), pharmaceutically active compounds (PhACs), pesticides, and personal care products (PCPs) at low concentrations (orders of ppb and ppt). Those trace organic compounds along with some inorganic compounds such as arsenic and hexavalent chromium found in reclaimed water are of special concern for human and ecological health risk. In addition, there are growing concerns among the public and the mass media with those trace contaminants in reclaimed water which were coincided with increasingly sensitive detection techniques that enabled detection of extremely low contaminant concentrations.

### III. Future directions for water reuse

In many parts of the world, agricultural irrigation using reclaimed water has been practiced for many centuries. Landscape irrigation such as irrigation of golf courses, parks and playgrounds has been successfully implemented in many urban areas for over 30 years. Salt management in irrigated croplands may require special attention in many arid and semi-arid regions. Beyond irrigation and non-potable urban reuse, indirect or direct potable reuse need careful evaluation and close public scrutiny. It is obvious from public health and acceptance standpoints that non-potable water reuse options must be exhaustively explored prior to any notion of indirect or direct potable reuse.

Groundwater recharge with reclaimed water and direct potable water reuse share many of the public health concerns encountered in drinking water withdrawn from polluted rivers and reservoirs. Three classes of constituents are of special concern where reclaimed water is used in such applications: (1) enteric viruses and other emerging pathogens; (2) organic constituents including industrial and pharmaceutical chemicals, residual home cleaning and personal care products and other persistent pollutants; and (3) salts and heavy metals. The ramifications of many of these constituents in trace quantities are not well understood with respect to long-term health effects. For example, there are concerns about exposure to chemicals that may function as endocrine disruptors; also the potential for development of antibiotic resistance is of concern. As a result, regulatory agencies are proceeding with extreme caution in permitting water reuse applications that affect potable water supplies. In each case in the United States where potable water reuse has been contemplated, alternative sources of water have been developed in the ensuing years and the need to adopt direct potable water reuse has been avoided. As the proportional quantities of treated wastewater discharged into the receiving water increases, much of the research which addresses groundwater recharge and potable water reuse is becoming of equal relevance to *unplanned direct potable reuse* such as municipal water intakes located downstream from wastewater discharges or from increasingly polluted rivers and reservoirs. Examples include the Sacramento River, the Santa Ana River, and the Clear Lake.

Reclaimed water is a locally controllable water resource that exists right at the doorstep of the urban environment, where water is needed the most and priced the highest. Closing the loop of the water cycle not only is technically feasible in industries and municipalities but also makes economic sense. While potable reuse is still a distant possibility and may never be implemented in California, groundwater recharge with advanced wastewater treatment technologies is a viable option backed by the decades of experiences in many parts of the world. Water reuse has become an essential element of future water resources development in integrated water resources management; thus, our opportunities and challenges will continue well into the 21<sup>st</sup> century.

### IV. Specific issues charged to the Science and Health/Indirect Potable Reuse Workgroup

#### 1. Charges

The main charge of the Science and Health Issues/Indirect Potable Reuse workgroup is to examine the issues listed in the matrix, examine the scientific basis for current reuse standards, address the importance of emerging issues of scientific and public health concern, identify any areas of research needs, and substantiate the need to reconvene the California Indirect Reuse Committee and suggest its scope of work, and make any other recommendations to remove impediments to water reuse.

#### 2. Issues

- ◆ Groundwater recharge
- ◆ Surface water augmentation
- ◆ Applied research on wastewater reuse by academic institutions
- ◆ Pharmaceutical and trace elements
- ◆ Construction, design, operation & maintenance
- ◆ Testing and certification to insure safe use
- ◆ Epidemiological studies update to provide current assessment of the science regarding public health and water reuse

**Groundwater recharge.** State of California has been in the forefront of providing regulatory guidance in groundwater recharge with reclaimed wastewater. The State of California Interagency Water Reclamation Coordinating Committee has conducted the Scientific Advisory Panel during 1986-87 and issued the *Report of*

*the Scientific Advisory Panel on Groundwater Recharge with Reclaimed Wastewater* in November 1987. Based on the Scientific Advisory Panel Report, groundwater recharge criteria with reclaimed wastewater were drafted by the Department of Health Services in late 1980s and the Draft Criteria have been updated several times with the most recent version issued in April 2001.

**Applied research on wastewater reuse by academic institutions.** University of California has prepared an umbrella research proposal entitled, “Strategies for Water Reuse in California” and being submitted to the California State Water Resources Control Board, California Department of Water Resources, and the U.S. Bureau of Reclamation. This proposal will assess the broad scientific foundations of water recycling and reuse in California and extend these foundations in several critical areas. The overall intent of this program is to simultaneously establish and improve the broad scientific underpinnings of water reuse in the context of California’s water supply, wastewater, and environmental problems as well as establish a firm presence of California-based University researchers in the water reuse field. This second objective should be of longstanding value to California by providing a steady supply of advanced professionals and a local venue for fundamental and applied research in this field. By having a range of research conducted under a single program, greater collaboration and integration of findings will occur among researchers, and a broader base for long-term University involvement in reuse research, teaching, and service will be established.

**Epidemiological studies update to provide current assessment of the science regarding public health and water reuse.** A possibility of reconvening the California Potable Reuse Committee to look into the issues related to groundwater recharge with reclaimed wastewater must be discussed. In addition, research study may investigate a framework for decision-making in regulatory process related to groundwater recharge with reclaimed wastewater. The research may specifically focus on the rational basis for evaluating chemical contaminants, especially the fate of trace contaminants during groundwater recharge and their associated health risks. Specific objectives of this study are to: (1) establish the database for trace contaminants in water and reclaimed wastewater and evaluate their potential risks; thereby, prioritize the chemical compounds of concern in terms of relative health effects in humans, (2) propose a guideline to manage emerging anthropogenic contaminants in water and reclaimed wastewater, (3) evaluate health risks associated with groundwater recharge with reclaimed wastewater and provide management options for emerging contaminants based on scientific and rational bases in support for regulatory process.

**Issue of reconvening the California Indirect Potable Reuse Committee.** After extensive discussions among the Workgroup members, recommendation was made not to reconvene the California Indirect Potable Reuse Committee. The State of California Department of Health Services should be able to make informed and scientific determinations on issues related to indirect potable reuse based on the following publications.

- “Report of the Scientific Advisory Panel on Groundwater Recharge with Reclaimed Wastewater”, Prepared for State of California, State Water Resources control Board, Department of Water Resources, and Department of Health Services, November 1987.
- “Issues in Potable Reuse – The viability of augmenting drinking water supplies with reclaimed water”, National Research Council, 1998.

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